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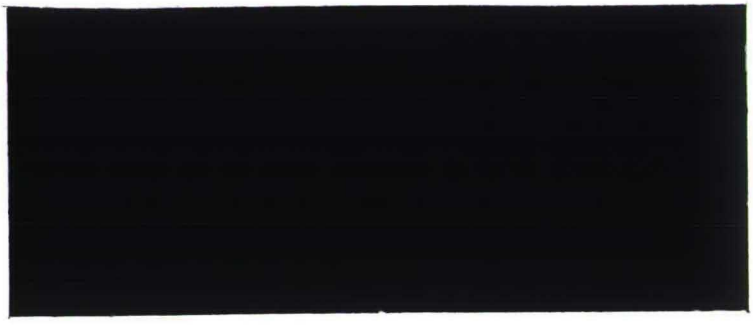
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DEPARTMENT OF ECONOMICS
RESEARCH MEMORANDUM



EUROPEAN CENTRAL BANK INDEPENDENCE
AND INFLATION PERSISTENCE

Drs. E. Schaling

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EUROPEAN CENTRAL BANK INDEPENDENCE AND INFLATION PERSISTENCE

by

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RESEARCH MEMORANDUM DEPARTMENT OF ECONOMICS TILBURG UNIVERSITY

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ABSTRACT

This paper analyses the relation between European inflation dynamics and the transition from the EMS regime towards monetary union. On the basis of a two-country New-Classical model with overlapping contracts it is shown that greater European central bank independence - in the sense of lower monetary financing of European government deficits - reduces both inflation and inflation persistence. These conclusions are consistent with recent empirical research by Alesina (1989) and Alogoskoufis (1990).

Keywords: Monetary Integration, EMU, EMS, Inflation, Monetary Accommodation, Rational Expectations
JEL Classification: 430, 121, 134

¹⁾ This version was presented at the Sixth Congress of the European Economic Association August 31 - September 2, 1991 Cambridge U.K.

EUROPEAN CENTRAL BANK INDEPENDENCE AND INFLATION PERSISTENCE ²⁾

1. Introduction

A recent study by Alberto Alesina (1989,p.81) ranks central banks according to an index of political independence. Alesina defines independence via objective indicators such as the formal institutional relationship between the central bank and the government and the existence of rules forcing the central bank to automatically accomodate fiscal policy.

In empirical research which was also published in a special issue of *European Economy* (1990, pp.97-98) Alesina used these indicators to establish a measure of independence which was then compared with the average inflation rate. By and large, the more independent the central bank, the lower the inflation rate. For the period of the study, 1973-1986 in Europe the Banca d'Italia was one of the least independent central banks and West Germany's Bundesbank the most so. Inflation figures for these two countries are presented in table 1.

Simple computations yield an average inflation-differential for the period 1983-1989 of 6,4 percentage points.

It is also evident from table 1. that in the 1980s a considerable part of the Italian central government deficit was financed by monetary means. After the 'divorzio' in 1981 the CICR ³⁾ no longer required the Banca d'Italia to absorb all excess supplies on the market for short-term treasury bills (Buoni Ordinarie del Tesoro and Certificati di Credito del Tesoro (indexed)). Still in 1985 more than 22% of the deficit was financed by issuing assets which fall in the definition of high powered money. In July 1991 a next step was taken on the road towards more independence. A bill was passed that makes the president of the Banca d'Italia the sole competent authority in setting official interest rates.⁴⁾

In the section of the 'Delors report' concerning the principal features of Economic and

²⁾ I am grateful for helpful comments by Matthew Canzoneri, Theo van de Klundert, Rick van der Ploeg, Lex Meydam, Jacques Smulders and participants in a Phd-seminar at Tilburg University. Of course the usual disclaimer applies. Also I am grateful for cooperation by the External Relations and Information Department of De Nederlandsche Bank, and by the Research Department of NMB Postbank. Mrs Rennie Meijer, Miss Jolanda Bakhuys and Mrs Marja Speekenbrink typed the manuscript. George Alogoskoufis' visit at CEnTER for Economic Research (October 1990) inspired me to write the paper. It is written in the framework of the NWO research project "Rules versus discretion in the conduct of short-term macroeconomic stabilization policies under uncertainty" (450-226-017). Financial support from NWO is gratefully acknowledged.

³⁾ The CICR (Comitato Interministeriale per il Credito e il Risparmio) - chaired by the Treasury - is the utmost authority on monetary policy and sets directives for the Banca d'Italia. For an interesting discussion about the 'divorzio' see Tabellini (1988).

⁴⁾ However in the last ten years - in crises of confidence - Banca d'Italia conducted several interventions on behalf of the public. This practice gave rise to the following pun in the *Bonner Börsen-Zeitung* of July 30: " (...) Vor zehn Jahren sei auf die Ehe zwischen Zentralbank und Schatzamt nicht die Scheidung, sondern ein Konkubinat gefolgt."

Monetary Union (EMU) in the budgetary field binding rules are required that would exclude access to direct central bank credit and other forms of monetary financing (Delors Report 1989, p. 24).

Table 1: Italian budget deficits and monetary accomodation ⁵⁾

Year	'83	'84	'85	'86	'87	'88	'89
Budget deficit central government (% GDP)	10,7	11,5	12,5	11,4	11,7	11,6	11,0
Public debt (% GDP)	66,7	70,9	78,4	83,2	87,7	91,8	92,9
Financing by monetary means (% deficit)	5,1	10,5	22,4	10,0	8,1	2,1	- 1,0
Inflation	14,6	10,8	9,2	5,9	4,7	5,0	6,5
P.M. German inflation	3,3	2,4	2,2	- 0,2	0,2	1,3	2,8

Moreover in November 1990 the Draft Statute of the European System of Central Banks and of the European Central Bank was presented to the ECOFIN-Council in Madrid. Article 7 concerns independence and reads:

"In exercising the powers and performing the tasks and duties conferred upon them by the Treaty and this Statute, neither the ECB nor a national central bank nor any member of their decision-making bodies may seek or take any instructions from Community Institutions, governments or Member States or any other body. The Community and each member State undertake to respect this principle and not seek to influence the ECB, the national central banks and the members of their decision-making bodies in the performance of their tasks." ⁶⁾

Therefore the transition from the EMS to European Monetary Union will increase central bank independence and - if Alesina is right - lower European inflation rates.

In an interesting paper G. Alogoskoufis (1990) investigates the relation between the dynamics of inflation and monetary regimes. He demonstrates that fixed exchange-rate systems like the international gold standard and the Bretton-Woods gold dollar standard appear to be associated with negligible persistence of inflation, while regimes of managed exchange rates are associated with very high inflation persistence. He uses an overlapping wage contracts model to propose that the higher inflation persistence is the result of the higher monetary and exchange rate accomodation of price changes in flexible exchange rate regimes.

The purpose of this paper is to analyse the relation between European inflation dynamics

⁵⁾ Source: Eijffinger and Gerards (1991), p. 76, pp. 129 - 136.

⁶⁾ See Committee of Governors (1991), p. 3.

and the transition from the EMS regime towards monetary union. This transition will decrease the scope for accomodating (discretionary) monetary policy and therefore influence European inflation persistence.

On the basis of a New-Classical two-country real exchange rate overshooting model with fixed exchange rates and overlapping wage contracts ⁷⁾ we show that an increase in the fraction of the European government budget deficit that is financed by selling monetary assets to the ESCB results in an increase in the degree of persistence of European inflation.

The plan of this paper is as follows. In section 2 the model will be presented. In section 3 the analysis is simplified by defining averages and differences. The steady state is solved in section 4. In section 5 the solution to the dynamic adjustment is presented. Monetary and fiscal policy are made endogenous by the introduction of rules in section 6, also with the monetary rule an index of central bank independence is introduced. Finally the main theoretical result of the paper is obtained in section 7, whilst a summary and questions for further research are to be found in section 8.

2. The Model

The EMU consists of two countries -say Germany and Italy- that are of similar size and structure.

In presenting the model we focus on the equations of Germany; the Italian variables are denoted by an asterisk. The variables i and r are ratios expressed as arithmetic differences from their steady state values, all other variables are logarithmic deviations from steady state values. Exogenous variables are barred.

$$(1.1) \quad y = \omega_1 (p - w) + y_n \quad \omega_1 > 0$$

$$(1.2) \quad w = (1-\Theta)E_{t-1} \sum_{i=0}^{\infty} \Theta^i p_{ct+i} \quad 0 < \Theta < 1$$

$$(1.3) \quad y = g - a_1 (i - E_t p_{ct+1} + p_c) + a_2 y^* + a_3 q + u$$

$$0 < a_2 < 1 \quad a_1 > 0 \quad a_3 > 0$$

$$(1.4) \quad p_c = p + \mu q \quad \frac{1}{2} < \mu < 1$$

$$(1.5) \quad m - p = b_1 y - b_2 i + v \quad b_1 > 0, b_2 > 0$$

$$(1.6) \quad i = i^*$$

$$(1.7) \quad q = (p^* + \underline{e} - p)$$

⁷⁾ In the 'economics of EMU' literature overlapping contracts models are widely used. See for instance A. Hallet and D. Vines (1991) and M. Lossani and P. Tirelli (1991).

$$(1.8) \quad \zeta m + (1-\zeta)(m^* + e) = \underline{m}^a \quad ^8)$$

Where

· E is the expectations operator

· F is the forward shift (lead) operator

· L is the backward shift (lag) operator

· endogenous variables include

y (aggregate supply/demand)

i (the nominal interest rate),

p (the producers' price),

p_c (the CPI),

q (the real exchange rate),

m (the nominal money supply),

w (the nominal wage)

· The shock terms are u and v, each of which is white noise:

$$u_t \sim N(0, \sigma_u^2)$$

$$v_t \sim N(0, \sigma_v^2)$$

As regards equation (1.2) we assume that the European economies are characterized by staggered wage contracts (Taylor 1979, 1980).

Following Alogoskoufis (1990) we use the Calvo (1983) variant of the Taylor model, according to which each contract has a fixed probability $1 - \Theta$ of being re-opened in each period. Thus, Θ is the proportion of wage contracts that are not renewed in any particular period, and is a measure of the degree of nominal wage and price sluggishness.

As contract wages reflect expected inflation, after substituting (1.2) in (1.1.) one obtains the expectations augmented Phillips curve. Of course y_n denotes the natural level of

⁸⁾ The case of German hegemony in the EMS would of course be an interesting alternative specification. In that case we have (1.8 b) $m = \underline{m}$. See Giavazzi and Giovannini (1989).

output, and ω_1 describes production technology⁹⁾.

It should be noted however that the supply side of the model differs in major respects from that of Alogoskoufis. The latter paper features monopolistic competition, with prices a mark-up over unit labour costs. In the labour market nominal wages also reflect expected unemployment. Therefore the supply side of the Alogoskoufis model can be labelled 'Neo-Keynesian'.

Instead we assume perfect competition, market clearing and no effect of expected unemployment on nominal wages. If $\theta \neq 0$ in the short run the model has Keynesian features and policy invariance (Sargent and Wallace (1975)) does not hold. However due to real wage rigidity in the long run (see section 4) money is neutral and the model has Classical features. Therefore following Meydam (1991 p. 41) our supply side is of the 'New-Classical Synthesis' type.

Aggregate demand depends upon the real exchange rate, the real interest rate, foreign output, a fiscal shock g and a stochastic IS-shock u .

Equation (1.4) describes the home consumer price index (CPI). We assume $\mu > 1/2$, so residents in both countries have a preference for their own good.

Demand for real balances is a function of income, the nominal interest rate and a stochastic LM-shock v .

Perfect capital mobility (no capital controls), perfect asset substitutability, and irrevocably fixed exchange rates ensure that European nominal interest rates are equalized. The Board of Central Bank Governors (BCBG) of the ESCB sets the European money supply (\bar{m}^a).

¹⁰⁾ The parameter ζ represents the German share in the initial European money supply. Use of interest rates rather than the money stock corresponds to actual practice. However, because we want to avoid the "indeterminacy of the price level" critique (Sargent and Wallace (1975)), we choose an easy way out.¹¹⁾

The equations for the foreign country (Italy) are symmetric to the equations (1.1) - (1.5). Therefore the model consists of 13 independent equations.

3. Averages and Differences

The analysis can be simplified (Aoki (1981)) by defining the averages and differences for any variable x , say,

$$x^a \equiv 1/2 (x + x^*)$$

$$x^d = (x - x^*)$$

⁹⁾ In the remainder of this paper following Alesina and Grilli (1991) we normalize y_n and y_n^* at zero. In the case of a linear homogenous CES production function $y = \alpha l + (1 - \alpha)k$, ω_1 would be given by $\omega_1 = \alpha/(1 - \alpha)$.

¹⁰⁾ We follow Alberto Giovannini's (1990) blueprint for the ESCB's agencies.

¹¹⁾ Of course an alternative would be to specify an interest rate rule aimed at keeping the price level at a certain target.

The model can then be re-written in terms of the following decoupled system

European averages

$$(3.1) y^a = \omega_1 (p^a - w^a)$$

$$(3.2) w^a = \frac{(1-\theta)}{(1-\theta F)} E_{t-1} p^a$$

$$(3.3) (1 - a_2)y^a = g^a + u^a - a_1 i^a + a_1 E_t \Delta p_{t+1}^a$$

$$(3.4) m^a - p^a = b_1 y^a - b_2 i^a + v^a$$

$$(3.5) i^a = i$$

$$(3.6) m^a = \underline{m}^a$$

Equations (3.1) - (3.6) describe the aggregate European economy. Note that in the absence of nominal rigidities ($\theta = 0$) aggregate supply (3.1) is described by a standard Lucas-surprise function according to which deviations from the natural rate (which was normalized at zero) depend upon unanticipated inflation. To see this we take a closer look at equation (3.2). Setting $\theta = 0$ yields

$$(3.2') w^a = E_{t-1} p^a$$

Substitution of (3.2') in (3.1) yields:

$$(3.1') y^a = \omega_1 (p^a - E_{t-1} p^a)$$

which is a standard Lucas-surprise function. The Board of Central Bank Governors (BCBG) of the ESCB sets the European money supply, so m^a is exogenous.

National differences

$$(3.7) y^d = \omega_1 (p^d - w^d)$$

$$(3.8) w^d = \frac{(1-\theta)}{(1-\theta F)} E_{t-1} p_c^d$$

$$(3.9) (1 + a_2) y^d = g^d + 2a_3 q + u^d - a_1 i^d + a_1 E_t \Delta p_{t+1}^d$$

$$(3.10) m^d - p^d = b_1 y^d - b_2 i^d + v^d$$

$$(3.11) \ i^d = 0$$

$$(3.12) \ p_c^d = (1 - 2\mu) p^d$$

$$(3.13) \ p^d = -q$$

Equations (3.7) - (3.13) describe the differences in the two economies. Differences in fiscal stance (equation (3.8)) are exogenous. Because the intra-European nominal exchange rate is irrevocably fixed money stock differentials are endogenous. For notational convenience in the remainder of the paper we quit 'barring' exogenous variables.

4. Steady State

Since the analysis is based on rational expectations, the dynamics is determined in part by the steady state. It is therefore convenient to begin with a characterization of this equilibrium. Denoting the steady state by overbars, it is attained when

$$E_t F p_{ct}^{(*)} = E_t p_{ct}^{(*)} = p_{ct}^{(*)} \text{ }^{12)}$$

Thus the equilibrium in the goods and money markets of the two economies is

$$(4.1) \ \bar{y} = \omega_1 (\bar{p} - \bar{w})$$

$$(4.2) \ \bar{w} = \bar{p}_c$$

$$(4.3) \ \bar{y} = \bar{g} - a_1 \bar{i} + a_2 \bar{y}^* + a_3 \bar{q} + \bar{u}$$

$$(4.4) \ \bar{p}_c = \bar{p} + \mu \bar{q}$$

$$(4.5) \ \bar{m} - \bar{p} = b_1 \bar{y} - b_2 \bar{i} + \bar{v}$$

$$(4.6) \ \bar{i} = \bar{i}^*$$

$$(4.7) \ \bar{q} = -\bar{p}^d$$

The equations for Italy are symmetric to equations (4.1) - (4.5). Note that according to equation (4.2) in the long run real wage rigidity (RWR) holds; in the long run money wages are fully indexed to the CPI. The solutions to these equations are

$$(4.13) \ \bar{y} = -\mu \omega_1 \bar{q}$$

$$(4.14) \ \bar{y}^* = \mu \omega_1 \bar{q}$$

¹²⁾ An alternative condition is $E_t F p_t^{a,d} = E_t p_t^{a,d} = p_t^{a,d}$.

$$(4.15) \bar{q} = \frac{-1}{2(1 + a_2)\mu\omega_1 + 2a_3} (\bar{g}^d + \bar{u}^d)$$

$$(4.16) i = \frac{1}{a_1} (\bar{g}^a + \bar{u}^a)$$

$$(4.17) \bar{p} = \frac{b_2}{a_1} (\bar{g}^a + \bar{u}^a) + \frac{1}{4(1 + a_2)\mu\omega_1 + 4a_3} (\bar{g}^d + \bar{u}^d) - \bar{v}^a + \bar{m}^a$$

$$(4.18) \bar{p}^* = \frac{b_2}{a_1} (\bar{g}^a + \bar{u}^a) - \frac{1}{4(1 + a_2)\mu\omega_1 + 4a_3} (\bar{g}^d + \bar{u}^d) - \bar{v}^a + \bar{m}^a$$

$$(4.19) \bar{p}_c = \frac{b_2}{a_1} (\bar{g}^a + \bar{u}^a) + \frac{(1 - 2\mu)}{4(1 + a_2)\mu\omega_1 + 4a_3} (\bar{g}^d + \bar{u}^d) - \bar{v}^a + \bar{m}^a$$

$$(4.20) p_c^* = \frac{b_2}{a_1} (\bar{g}^a + \bar{u}^a) - \frac{(1 - 2\mu)}{4(1 + a_2)\mu\omega_1 + 4a_3} (\bar{g}^d + \bar{u}^d) - \bar{v}^a + \bar{m}^a$$

$$(4.21) \bar{m} = \frac{(1 + 2\mu\omega_1 b_1)}{4(1 + a_2)\mu\omega_1 + 4a_3} (\bar{g}^d + \bar{u}^d) + \frac{1}{2} \bar{v}^d + \bar{m}^a$$

$$(4.22) \bar{m}^* = \frac{-(1 + 2\mu\omega_1 b_1)}{4(1 + a_2)\mu\omega_1 + 4a_3} (\bar{g}^d + \bar{u}^d) - \frac{1}{2} \bar{v}^d + \bar{m}^a$$

Note that given exogenous averages and differences (x^d , x^a) home and foreign exogenous variables follow from

$$x \equiv x^a + \frac{1}{2} x^d$$

$$x^* \equiv x^a - \frac{1}{2} x^d$$

Assuming no random shocks ($\bar{v}^a = \bar{v}^d = \bar{u}^d = 0$) from (4.16) it is seen that, in the long run, an increase in government expenditure at home or abroad will raise the steady state nominal/real interest rate equally. From (4.15) it is seen that an increase in domestic government expenditure ($\bar{g}^d > 0$) will raise the relative price of domestic goods (\bar{p}^d), thus lowering the real exchange rate \bar{q} .

The home real appreciation lowers the consumers' wage (4.2) below the producers' wage thereby boosting home output (4.13) and lowering foreign output (4.14).

Thus a fiscal expansion is a beggar-thy-neighbour policy.

Because of the real appreciation a home fiscal expansion moves the home current account into deficit. Since all fiscal expansions are bond financed¹³⁾ the home capital account is moved towards surplus.

In general the net outcome depends on the values of b_1 , a_2 , b_2 , a_3 , ω_1 , μ and the interest sensitivity of international capital movements (χ).

Formally a home fiscal expansion will generate a balance of payments surplus if

$$\chi > \frac{b_2(a_3 + 2\mu\omega_1 a_2)}{1 + 2\mu\omega_1 b_1} \quad 14).$$

Thus, a surplus is more likely the greater is the interest sensitivity of international capital movements (χ) and the income sensitivity of the demand for money (b_1), and the smaller is the marginal propensity to import (a_2), the interest sensitivity of the demand for money (b_2) and the elasticity of substitution between home and foreign goods (a_3).

Since we assumed perfect capital mobility ($\chi \rightarrow \infty$) to be the typical case the capital account effect will dominate.

Therefore a home fiscal expansion will trigger (net) capital flows from the foreign country to the home country thereby increasing the home nominal money stock (4.21) and decreasing the foreign nominal money stock. Due to RWR an increase in the European money supply (\bar{m}^a) will lead to equiproportionate increases in home and foreign wages and prices (\bar{p} , \bar{p}^* , \bar{p}_c , \bar{p}_c^* , \bar{w} , \bar{w}^*) and has no real effects.

5. Solutions to Dynamics

The solution to the dynamic adjustment of the economy is obtained in two parts, first for the differences then for the averages. These solutions can then be transformed to the original variables

National Differences

The differential demand curve can be obtained by substitution of (3.12) and (3.13) in (3.9) (see section 3)

$$(5.1) \quad y^d = \frac{1}{(1 + a_2)}(g^d + u^d) + \frac{2a_3}{(1 + a_2)} q - \frac{a_1(1 - 2\mu)}{(1 + a_2)} E_t \Delta q_{t+1}$$

The division of European demand between German (y) and Italian (y^*) goods depends positively on the differential fiscal stance and the real exchange rate.

¹³⁾ Monetary accommodation (monetization) of deficits is introduced in section 6.

¹⁴⁾ See appendix A.

The only ambiguous sign in (5.1) is sign $\left[\frac{a_1(1 - 2\mu)}{(1 + a_2)} \right]$.

Since we assumed that residents in both countries have a preference for their own good

$$(\mu > 1/2) \text{ sign } \left[\frac{a_1(1 - 2\mu)}{(1 + a_2)} \right] < 0$$

Therefore an expected real appreciation shifts European demand towards Italian goods. The differential surprise supply function can be obtained by substituting nominal wage differentials (3.8) in the differential supply curve (3.7)

$$(5.2) \quad y^d = \omega_1 \left(1 - \frac{(1 - \theta)(1 - 2\mu)}{(1 - \theta F)} E_{t-1} \right) p^d$$

Equating (5.1) and (5.2) (market-clearing) yields the following dynamic equation for the European inflation differential ¹⁵⁾

$$(5.3) \quad \left(\frac{\omega_1(1 + a_2) + 2a_3}{\omega_1(1 + a_2)} - \frac{(1 - \theta)(1 - 2\mu)}{(1 - \theta F)} E_t - 1 - \frac{a_1(F - 1)(1 - 2\mu)}{\omega_1(1 + a_2)} E_t \right) p^d = \frac{1}{\omega_1(1 + a_2)} (g^d + u^d)$$

Note that if $E_{t-1} = E_t = F = 1$ this equation reduces to the steady state solution for the real exchange rate; i.e. equation (4.15).

Using the fact that F and L operate on time subscripts of variables (not on the time at which the expectation of that variable is held) and that $E_t p_t^d = p_t^d$, on multiplying both sides of (5.3) with $L(1 - \theta F)$ we end up with the following second order expectational difference equation for European inflation differentials

$$(5.4) \quad p_t^d = \alpha E[p_{t+1}^d | t] + \beta p_{t-1}^d + x_t^d$$

where

$$\alpha \equiv \frac{\theta a_1(1 - 2\mu)}{\Lambda}$$

¹⁵⁾ And using $q = -p^d$.

$$\beta \equiv \frac{\omega_1(1 + a_2)[1 - (1 - \theta)(1 - 2\mu)] + 2a_3 + a_1(1 - 2\mu)}{\Lambda}$$

$$x_t^d \equiv \frac{(\theta - L)}{\Lambda}(g^d + u^d)$$

$$\Lambda \equiv \theta[\omega_1 + (1 + a_2) + 2a_3 + a_1(1 - 2\mu)] + a_1(1 - 2\mu)$$

This equation is solved in Appendix B using factorization. For the moment we focus on the expected inflation differential conditional on information at $t-1$ that is

$$(B10) (F - \lambda_{1d})(F - \lambda_{2d})L E [p_t^d | t - 1] = \left(\frac{-1}{\alpha}\right) E [x_t^d | t - 1]$$

where $(F - \lambda_{1d})(F - \lambda_{2d})$ is the factored polynomial in the forward-shift operator, and λ_{1d} , λ_{2d} are the two roots of difference equation (B9) and are given by

$$\lambda_{1d}, \lambda_{2d} = \frac{1}{2\alpha} \pm \frac{1}{2} \sqrt{\frac{1}{\alpha^2} - \frac{4\beta}{\alpha}}$$

and the subscript "d" denotes the differences model.

If $|\lambda_{1d}| < 1$ and $|\lambda_{2d}| > 1$ the differences model will be saddlepoint-stable¹⁶⁾. Multiplying both sides of (B10) with F and some rearrangement yields

$$(5.5) E [p_t^d | t-1] = \frac{-1}{\alpha\{(F - \lambda_{1d})(F - \lambda_{2d})\}} E [x_{t+1}^d | t-1]$$

Since

$$(3.12) p_c^d = (1-2\mu) p^d$$

$$(5.6) E [p_{ct}^d | t-1] = \frac{-(1 - 2\mu)}{\alpha\{(F - \lambda_{1d})(F - \lambda_{2d})\}} E [x_{t+1}^d | t-1]$$

Substitution of (5.6) in the equation for nominal wage differentials

$$(3.8) w^d = \frac{(1 - \theta)}{(1 - \theta F)} E_{t-1} p_c^d$$

¹⁶⁾ See Begg (1982), p 42.

yields

$$(5.7) \quad w^d = \frac{(1 - \theta)}{1 - \theta F} \cdot \frac{-(1 - 2\mu)}{\alpha\{(F - \lambda_{1d})(F - \lambda_{2d})\}} E [x_{t+1}^d \mid t-1]$$

$$\text{since } -\frac{1}{(1 - \theta F)} \equiv \sum_{i=0}^{\infty} \theta^i F^i$$

(5.7) can be rewritten as

$$(5.8) \quad w^d = \frac{(\theta - 1)(1 - 2\mu)}{\alpha\{(F - \lambda_{1d})(F - \lambda_{2d})\}} \sum_{i=0}^{\infty} \theta^i F^i E [x_{t+i}^d \mid t-1]$$

or

$$(5.9) \quad w^d = \frac{(\theta - 1)(1 - 2\mu)}{\alpha\{(F - \lambda_{1d})(F - \lambda_{2d})\}} \sum_{i=0}^{\infty} \theta^i E [x_{t+i+1}^d \mid t-1]$$

In order to solve for the division of European output (y^d) we need the solution for the European inflation differential.

This solution is given¹⁷⁾ by

$$(5.10) \quad p^d = \frac{1}{(1 - \lambda_{1d}L)(1 - \alpha\lambda_{1d})} \sum_{i=0}^{\infty} \lambda_{2d}^{-i} E [x_{t+i}^d \mid t]$$

Substitution of (5.9) and (5.10) in

$$(3.7) \quad y^d = \omega_1 (p^d - w^d)$$

Gives

¹⁷⁾ It is obtained by using the lag operator in (B13).

$$(5.11) \quad y^d = \frac{\omega_1}{(1 - \lambda_{1d}L)(1 - \alpha\lambda_{1d})} \sum_{i=0}^{\infty} \lambda_{2d}^{-i} E [x_{t+i}^d | t] \\ - \frac{\omega_1(\theta - 1)(1 - 2\mu)}{\alpha\{(F - \lambda_{1d})(F - \lambda_{2d})\}} \sum_{i=0}^{\infty} \theta^i E [x_{t+i+1}^d | t-1]$$

Finally endogenous money stock differentials are simply

$$(3.10) \quad m^d = p^d + b_1 y^d + v^d$$

Substitution of (5.10) and (5.11) in (3.10) gives

$$(5.12) \quad m^d = \frac{(1 + \omega_1 b_1)}{(1 - \lambda_{1d}L)(1 - \alpha\lambda_{1d})} \sum_{i=0}^{\infty} \lambda_{2d}^{-i} E [x_{t+i}^d | t] \\ - \frac{\omega_1 b_1(\theta - 1)(1 - 2\mu)}{\alpha\{(F - \lambda_{1d})(F - \lambda_{2d})\}} \sum_{i=0}^{\infty} \theta^i E [x_{t+i+1}^d | t-1] + v^d$$

European Averages

The demand curve for European goods can be obtained by combination of IS curve (3.3) with LM curve (3.4)

$$(5.13) \quad y^a = \sigma_1 (m^a - p^a - v^a) + \sigma_2 (g^a + u^a) + \sigma_3 E_t \Delta p_{t+1}^a$$

where

$$\sigma_1 \equiv \frac{a_1}{((1 - a_2)b_2 + a_1 b_1)}$$

$$\sigma_2 \equiv \frac{b_2}{((1 - a_2)b_2 + a_1 b_1)}$$

$$\sigma_3 \equiv \frac{a_1 b_2}{((1 - a_2)b_2 + a_1 b_1)}$$

Therefore the demand for European goods depends positively on real money balances, the fiscal stance and expected inflation. Of course σ_1/σ_2 measures the relative efficacy of monetary versus fiscal policy.

The aggregate surprise supply function is obtained by substitution of the wage equation (3.2) in the supply curve (3.1):

$$(5.14) \quad y^a = \omega_1 \left(1 - \frac{(1 - \theta)}{(1 - \theta F)} E_t - 1\right) p^a$$

Equilibrium in the goods market is attained when (5.1) = (5.2)

Thus

$$(5.15) \quad \omega_1 \left(1 - \frac{(1 - \theta)}{(1 - \theta F)} E_{t-1}\right) p^a = \sigma_1(m^a - p^a - v^a) + \sigma_2(g^a + u^a) + \sigma_3 E_t \Delta p_{t+1}^a$$

On multiplying both sides of (5.15) with $L(1 - \theta F)$ and using the definitions of lag- and forward-shift operators we end up with the following second order expectational difference equation for the European price level:

$$(5.16) \quad p_t^a = \gamma E[p_{t+1}^a | t] + \delta p_{t-1}^a + x_t^a$$

$$\text{where } \gamma = \frac{\sigma_3 \theta}{\Gamma}$$

$$\delta = \frac{\sigma_1 + \sigma_3 + \omega_1 \theta}{\Gamma}$$

$$x_t^a = \frac{(\theta - L)}{\Gamma} (\sigma_1(m^a - v^a) + \sigma_2(g^a + u^a))$$

$$\Gamma = \theta(\omega_1 + \sigma_1 + \sigma_3) + \sigma_3$$

Transforming Differences Results to Averages Results

Note that the dynamic structure of (5.16) is exactly like the one prevailing in the differences model, i.e. equation (5.4).

Therefore we can transform the results for the differences model to the averages model by setting $\alpha = \gamma$, $\beta = \delta$, $\mu = 0$ and "d" = "a".

The averages analogon of (5.5) then becomes

$$(5.17) \quad E[p_t^a | t-1] = \frac{-1}{\gamma\{(F - \lambda_{1a})(F - \lambda_{2a})\}} E[x_{t+1}^a | t-1]$$

where λ_{1a} , λ_{2a} are the two roots of the averages analogon of (B9) and are given by

$$\lambda_{1a}, \lambda_{2a} = \frac{1}{2\gamma} \pm \frac{1}{2} \sqrt{\frac{1}{\gamma^2} - \frac{4\delta}{\gamma}}$$

If $|\lambda_{1a}| < 1$ and $|\lambda_{2a}| > 1$ the averages model will be saddlepoint-stable.

Substitution of (5.17) in

$$(3.2) \quad w^a = \frac{(1 - \theta)}{(1 - \theta F)} E_{t-1} p^a$$

yields

$$(5.18) \quad w^a = \frac{(\theta - 1)}{\gamma\{(F - \lambda_{1a})(F - \lambda_{2a})\}} \sum_{i=0}^{\infty} \theta^i E [x_{t+i+1}^a | t-1]$$

In order to solve for aggregate European output (y^a) we need the solution for the aggregate price level.

This solution is given by the averages analogon of (5.10)

$$(5.19) \quad p^a = \frac{1}{(1 - \lambda_{1a}L)(1 - \gamma\lambda_{1a})} \sum_{i=0}^{\infty} \lambda_{2a}^{-i} E [x_{t+i}^a | t]$$

Substitution of (5.18) and (5.19) in

$$(3.1) \quad y^a = \omega_1 (p^a - w^a)$$

gives

$$(5.20) \quad y^a = \frac{\omega_1}{(1 - \lambda_{1a}L)(1 - \gamma\lambda_{1a})} \sum_{i=0}^{\infty} \lambda_{2a}^{-i} E [x_{t+i}^a | t]$$

$$\frac{-\omega_1(\theta - 1)}{\gamma\{(F - \lambda_{1a})(F - \lambda_{2a})\}} \sum_{i=0}^{\infty} \theta^i E [x_{t+i+1}^a | t-1]$$

Finally the average nominal interest rate ($i^a = i = i^*$) follows from

$$(3.4) \quad m^a - p^a = b_1 y^a - b_2 i^a + v^a$$

Thus

$$(5.21) \quad i^a = \frac{1}{b_2} (p^a + v^a - m^a + b_1 y^a)$$

Substitution of (5.19) and (5.20) in (5.21) gives

$$(5.22) \ i^a = \frac{(1 + \omega_1 b_1)}{b_2(1 - \lambda_{1a}L)(1 - \gamma\lambda_{1a})} \sum_{i=0}^{\infty} \lambda_{2a}^{-i} E [x_{t+i}^a | t] \\ - \frac{\omega_1 b_1(\theta - 1)}{b_2\gamma\{(F - \lambda_{1a})(F - \lambda_{2a})\}} \sum_{i=0}^{\infty} \theta^i E [x_{t+i+1}^a | t-1] + \frac{1}{b_2} (v^a - m^a)$$

The solutions for averages and differences can be transformed to the original variables. Given averages and differences for any variable x , say, home and foreign variables follow from

$$x \equiv x^a + \frac{1}{2} x^d \\ x^* \equiv x^a - \frac{1}{2} x^d$$

For example the solution for German output is simply a linear combination of equations (5.20) and (5.11); i.e.

$$y = (5.20) + \frac{1}{2} * (5.11).$$

6. Policy Rules and Central Bank Independence

In this section we focus on the averages model. Monetary and fiscal policy are made endogenous by the introduction of rules. Also with the monetary rule an index of central bank independence is introduced.

Monetary Policy

The standard expression for monetary accommodation of government budget deficits in a simple IS-LM model (Turnovsky 1977, p 71) is

$$(6.1) \ \Delta \hat{M} = \psi_0 (\hat{G} - t\hat{Y}) \quad 0 \leq \psi_0 \leq 1$$

Equation (6.1) says that a fraction ψ_0 of the (nominal) budget deficit is financed by bonds sold to the ESCB ("printing money"), the remaining $(1 - \psi_0)$ is financed by net private bond sales.

Of course t is the average tax rate and "hats" denote absolute values.

Abstracting from taxes ($t=0$), (6.1) can be rewritten in terms of logarithmic deviations from initial steady state values. Simple transformations lead to:

$$(6.2) \ \Delta m = \psi (g+p)^{18)}$$

Equation (6.2) can be rewritten as

¹⁸⁾ For a derivation of this formula see Appendix C.

$$(6.3) \quad m = \frac{\psi}{(1-L)} (g+p)$$

Next we replace equation

$$(1.8) \quad \zeta + (1 - \zeta)(m^* + \underline{e}) = m^a$$

by

$$(6.4) \quad m^a = \frac{\psi}{(1-L)} (g^a + p^a)$$

Therefore instead of being completely exogenous the European System of Central Banks now partly accommodates (monetizes) European government deficits.

Thus ψ is a parametrization of monetary accommodation and an index of central bank independence.

Fiscal Policy

Fiscal policy in the EMU stabilizes European GDP around its natural rate (y_n^a) level according to proportional policy rule (Phillips 1957)

$$(6.5) \quad g^a = -c_1 (y^a - y_n^a)$$

and c_1 is an index of countercyclical fiscal flexibility.

Substitution of monetary and fiscal rules in the expectational difference equation for the European price level, i.e. equation

$$(5.16) \quad p_t^a = \gamma E [p_{t+1}^a | t] + \delta p_{t-1}^a + x_t^a$$

$$\text{where } x_t^a \equiv \frac{(\theta-L)}{\Gamma} (\sigma_1(m^a - v^a) + \sigma_2(g^a + u^a))$$

and abstracting from issues concerning the relative efficacy of monetary and fiscal policy ($\sigma_1 = \sigma_2 = \sigma$) yields

$$(6.6) \quad p_t^a = \frac{\Pi(1 + \varphi) + \sigma\{c_1\omega_1(2 + \psi(2 - \theta)) - \psi\}}{\Pi(1 + \epsilon) + \theta\sigma(c_1\omega_1(1 + \psi) - \psi)} p_{t-1}^a - \frac{(\Pi\varphi + \sigma c_1\omega_1(2 - \theta))}{\Pi(1 + \epsilon) + \theta\sigma(c_1\omega_1(1 + \psi) - \psi)} p_{t-2}^a$$

$$\begin{aligned}
& + \frac{\epsilon}{\Pi(1 + \epsilon) + \theta\sigma(c_1\omega_1(1 + \psi) - \psi)} E[p_{t+1}^a | t] \\
& + \frac{(1 - L)}{\Pi(1 + \epsilon) + \theta\sigma(c_1\omega_1(1 + \psi) - \psi)} z_t^a
\end{aligned}$$

where

$$\epsilon \equiv \frac{\sigma_3}{\Pi}$$

$$\varphi \equiv \frac{\sigma + \sigma_3 + \omega_1\theta}{\Pi}$$

$$\Pi \equiv \theta(\omega_1 + \sigma + \sigma_3) + \sigma_3$$

$$z_t^a \equiv \frac{(\theta - L)}{\Pi} (\sigma(u^a - v^a) - y_n^a)$$

and y_n^a is normalized at zero;

$$\text{i.e. } y_n^a = 0$$

The dynamic structure of this equation is quite similar to that of (5.4) and (5.16) except for the presence of the two period lagged price level p_{t-2}^a . This result emerges because in this paper monetary accommodation is parametrized by means of rule (6.2). That is, money growth (Δm), rather than the level of the money stock is linked to the price level. In the Alogoskoufis paper the parametrization of reserve-and exchange rate regimes is entirely in levels¹⁹⁾ thereby avoiding higher (than second) order equations. As said because of rule (6.2) we end up with a third order expectational difference equation in the European price level.

However, the presence of p_{t-2}^a in (6.6) presents no particular problem²⁰⁾.

Define

$$(6.7) \quad n_t^a \equiv p_{t-1}^a$$

¹⁹⁾ See Alogoskoufis (1990), p 10.

²⁰⁾ For instance see Blanchard and Kahn (1980), p 1306.

where "n" denotes the new average variable.

Then expectational dynamics is governed by the system

$$(6.7) \quad n_t^a = p_{t-1}^a$$

$$(6.8) \quad p_t^a = \eta E[p_{t+1}^a | t] + \pi p_{t-1}^a + \# n_{t-1}^a + @(1-L) z_t^a$$

where

$$\eta \equiv \frac{\epsilon}{\Pi(1 + \epsilon) + \theta\sigma(c_1\omega_1(1 + \psi) - \psi)}$$

$$\pi \equiv \frac{\Pi(1 + \varphi) + \sigma\{c_1\omega_1(2 + \psi(2 - \theta)) - \psi\}}{\Pi(1 + \epsilon) + \theta\sigma(c_1\omega_1(1 + \psi) - \psi)}$$

$$\# \equiv \frac{-(\Pi\varphi + \sigma c_1\omega_1(2 - \theta))}{\Pi(1 + \epsilon) + \theta\sigma(c_1\omega_1(1 + \psi) - \psi)}$$

$$@ \equiv \frac{1}{\Pi(1 + \epsilon) + \theta\sigma(c_1\omega_1(1 + \psi) - \psi)}$$

$$z_t^a \equiv \frac{(\theta - L)}{\Pi} (\sigma(u^a - v^a) - y_n^a)$$

In the next section we will solve (6.8) and examine the sensitivity of the solution with respect to monetary accommodation.

That is, we will examine the relation between central bank independence and inflation persistence.

7. Central Bank Independence and Inflation Persistence

The main theoretical result of Alogoskoufis (1990) is that increases in the degree of monetary accommodation will result in an increase in the degree of persistence of inflation. This result is obtained in the following way. First a closed form solution for expected inflation is derived.

Next one takes the first derivative of the smaller (stable) root with respect to the degree of monetary accommodation.

If the sign of this derivative is (unambiguously) positive we get the (unconditional) persistence result. In this section we will establish our main theoretical result - greater European central bank independence reduces inflation persistence - in exactly the same manner.

We will solve

$$(6.8) \quad p_t^a = \eta E [p_{t+1}^a | t] + \pi p_{t-1}^a + \# n_{t-1}^a + @ (1-L) z_t^a$$

using factorization.

Next we will take the first derivative of the stable root with respect to the index of central bank independence.

Equation (6.8) can be rewritten as

$$(7.1) \quad p_t^a = \eta E [p_{t+1}^a | t] + \pi p_{t-1}^a + x_t^r$$

where

$$x_t^r = \# n_{t-1}^a + @ (1 - L) z_t^a$$

Note that the dynamic structure of (7.1) - the European price level under 'rules' - is exactly like

$$(5.16) \quad p_t^a = \gamma E [p_{t+1}^a | t] + \delta p_{t-1}^a + x_t^a$$

That is, the European price level under 'discretion'.

Therefore we can transform the results obtained under discretion to those under rules by setting

$$\gamma = \eta, \delta = \pi \text{ and } x_t^a = x_t^r$$

The solution to (5.16) is

$$(5.19') \quad p_t^a = \lambda_{1a} p_{t-1}^a + \left(\frac{1}{1-\gamma\lambda_{1a}} \right) \sum_{i=0}^{\infty} \lambda_{2a}^{-i} E [x_{t+i}^a | t]$$

Multiplying both sides with $(1 - L)$ yields

$$(5.19'') \quad \Delta p_t^a = \lambda_{1a} \Delta p_{t-1}^a + \left(\frac{1}{1-\gamma\lambda_{1a}} \right) \sum_{i=0}^{\infty} \lambda_{2a}^{-i} E [\Delta x_{t+i}^a | t]$$

Now we transform (5.19'') to the solution for European inflation under the prevailing monetary and fiscal rules. The result is

$$(7.2) \Delta p_t^a = \lambda_{1ar} \Delta p_{t-1}^a + \left(\frac{1}{1 - \eta \lambda_{1ar}} \right) \sum_{i=0}^{\infty} \lambda_{2ar}^{-i} E [\Delta x_{t+i}^r | t]$$

$$\text{where } \lambda_{1ar}, \lambda_{2ar} = \frac{1}{2\eta} \pm \frac{1}{2} \sqrt{\frac{1}{\eta^2} - \frac{4\pi}{\eta}}$$

and the subscript "ar" denotes the averages model under rules.

If the two roots lie on either side of unity the difference equation for expected European inflation under rules is saddlepoint stable.

From (7.2) one can see that the persistence of European inflation conditional on information at the end of period $t - 1$, is equal to λ_{1ar} .

Now we show how λ_{1ar} depends on the degree of central bank independence ψ .

First we express the characteristic equation (associated with the polynomial in the forward shift operator) as

$$(7.3) \rho^2 + b\rho + c$$

where $b = -(\lambda_{1ar} + \lambda_{2ar})$ and $c = \lambda_{1ar}\lambda_{2ar}$

The smaller root λ_{1ar} is given by,

$$(7.4) \lambda_{1ar} = -\frac{1}{2}b - \frac{1}{2}[b^2 - 4c]^{1/2}$$

Taking the first derivative of λ_{1ar} with respect to the degree of central bank independence ψ we find that it is given by,

$$\frac{\partial \lambda_{1ar}}{\partial \psi} = \frac{\partial \lambda_{1ar}}{\partial b} \cdot \frac{\partial b}{\partial \psi} + \frac{\partial \lambda_{1ar}}{\partial c} \cdot \frac{\partial c}{\partial \psi}$$

or

$$(7.5) \quad \frac{\partial \lambda_{1ar}}{\partial \psi} = \frac{(b^2 - 4c)^{-1/2}}{\epsilon} \{c_1 \omega_1 \sigma [\frac{\theta b}{2} + (2 - \theta)] - (\frac{\sigma \theta b}{2} + 1)\} + \frac{\sigma \theta}{2\epsilon} (c_1 \omega_1 - 1)$$

If $c_1 = \sigma = \omega_1 = 1$ this expression reduces to

$$(7.6) \quad \frac{\partial \lambda_{1ar}}{\partial \psi} = \frac{(b^2 - 4c)^{-1/2}}{\epsilon} \cdot (1 - \theta) > 0$$

From (7.6) it can be seen that an increase in the degree of European central bank independence - i.e. a decrease in ψ - reduces inflation persistence.

A maximum increase in persistence is obtained in the absence of nominal rigidities ($\theta = 0$), whilst more monetary accommodation has no effect on the degree of persistence in the

limit case of a zero re-opening probability.

The intuition behind (7.6) can be explained as follows.

As long as there is some fiscal flexibility ($c_1 \neq 0$), active stabilization policy is conducted.

Lower monetary accommodation of the resulting deficits lowers inflationary expectations. Since expected inflation falls, (new) reopened contracts will reflect these expectations, and the path of contract wages will be set lower than otherwise. These lower wages are reflected through the whole path of prices, with the net result being lower inflation persistence.

8. Summary and Questions for Further Research

Within the context of a two-country model with rational expectations, overlapping wage contracts and fixed exchange rates, it is shown that greater European central bank independence reduces both inflation and inflation persistence.

The first conclusion can be viewed as a 'rational expectations underpinning' of empirical research by Alesina (1989). The second concerns the relation between central bank independence and inflation dynamics and can therefore be viewed as a dynamic extension of the Alesina relation.

So far we studied monetary policy independent from fiscal policy. That is, in the model changes in fiscal flexibility were conducted irrespective of monetary accommodation.

However a key implication of the theory of financial restrictions is that monetary and fiscal policies must be coordinated (Sargent and Wallace (1984), Miller (1983), Buiter (1990)).

Therefore ignoring taxes and interest payments on government bonds first the government's flow budget constraint must be satisfied. That is the primary deficit must be financed either by printing more money or by issuing more bonds. In addition to the flow constraint we have to impose the terminal or transversality condition that the present discounted value of all future seigniorage revenues equals the present discounted value of all future primary deficits. This rules out everlasting 'Ponzi games': the government cannot forever increase its expenditures simply by increasing its seigniorage revenues.

If we exclude continuing wealth transfers from the private sector, more central bank independence today means less seigniorage revenues today and consequently less government spending (fiscal flexibility) tomorrow. Therefore an important item on our research agenda is to incorporate the flow- and transversality constraints in the model.

We expect that the inclusion of these constraints will reinforce our main theoretical result. For more central bank independence today will require less spending tomorrow. Since government expenditures have both real and nominal effects inflationary expectations today will fall thereby further lowering contract wages and inflation persistence.

Also important is the observation that I did not study a lot of issues that are central to the 'economics of EMU' literature. For instance no attention was paid to important institutional problems with regard to the management of a monetary union in Europe. A very fine essay concerning the latter is Giovannini (1990).

Also I sidestepped issues concerning the optimal size of the public sector and the optimal revenue mix for treasuries and central banks. This is discussed in Van der Ploeg (1990) and (1991). The conclusion of the latter paper is that in order to assess the case for an independent ESCB one should trade-off the welfare gains associated with enhanced

monetary discipline and lower inflation against the welfare losses associated with a sub-optimal government revenue mix.

Appendix A. Imperfect Capital Mobility

In this appendix we focus on the more general case of imperfect capital mobility. Equation (1.6) in section 1 is a special case of the BP curve

$$(A1) \ a_2 (y - y^*) - a_3 q - \chi (i - i^*) = 0$$

Where $[a_2 (y - y^*) - a_3 q]$ is the current account deficit whilst $\chi (i - i^*)$ are capital inflows.

If $\chi \rightarrow \infty$ (perfect capital mobility) this equation reduces to

$$(1.6) \ i = i^*$$

We will now solve the steady state two-country model with (1.6) replaced by (A1). Subtraction of (4.3) from (4.10) (see section 4) yields

$$(A2) \ (1+a_2) \bar{y}^d = (\bar{g}^d + \bar{u}^d) + 2a_3 \bar{q} - a_1 \bar{i}^d$$

where the steady state is denoted by overbars.

In the steady state (A1) is simply

$$(A1') \ a_2 (\bar{y} - \bar{y}^*) - a_3 \bar{q} - \chi (\bar{i} - \bar{i}^*) = 0$$

Thus

$$(A1'') \ \bar{i}^d = \frac{-a_3}{\chi} \bar{q} + \frac{a_2}{\chi} \bar{y}^d$$

Substitution of (A1') in (A2) gives

$$(A3) \ \frac{\chi(1 + a_2) + a_1 a_2}{\chi} \bar{y}^d = (\bar{g}^d + \bar{u}^d) + \frac{a_1 a_3 + 2a_3 \chi}{\chi} \bar{q}$$

From section 4 we know that

$$(4.13) \ \bar{y} = -\mu\omega_1 \bar{q}$$

and

$$(4.14) \ \bar{y}^* = \mu\omega_1 \bar{q}$$

Thus (4.13) -/- (4.14)

$$(A4) \bar{y}^d = -2\mu\omega_1 \bar{q}$$

Combining (A4) with (A3) and re-arranging terms gives the solution to the steady state real exchange rate (\bar{q}) under imperfect capital mobility

$$(A5) \bar{q} = \frac{-1}{(2\mu\omega_1(1 + a_2) + 2a_3) + a_1(2\mu\omega_1 a_2 + a_3)\chi^{-1}} (\bar{g}^d + \bar{u}^d)$$

Equation (3.10) (see section 3) in steady state is simply

$$(A6) \bar{m}^d = \bar{p}^d + b_1 \bar{y}^d - b_2 \bar{i}^d + \bar{v}^d$$

where

$$(3.13) p^d = -q$$

Thus

$$(A6') \bar{m}^d = -\bar{q}^d + b_1 \bar{y}^d - b_2 \bar{i}^d + \bar{v}^d$$

Substitution of (A4) in (A1'') gives

$$(A7) \bar{i}^d = \frac{-(a_3 + 2\mu\omega_1 a_2)}{\chi} \bar{q}$$

Substitution of (A7), (A5) and (A4) in (A6') in yields

$$(A8) \bar{m}^d = \frac{\chi(1 + 2\mu\omega_1 b_1) - b_2(a_3 + 2\mu\omega_1 a_2)}{(2\mu\omega_1(1 + a_2) + 2a_3)\chi + a_1(2\mu\omega_1 a_2 + a_3)} (\bar{g}^d + \bar{u}^d) + \bar{v}^d$$

Of course

$$(A9) \bar{m} = \bar{m}^a + \frac{1}{2} \bar{m}^d$$

Suppose the Board of Central Bank Governors of the ESCB keeps the European money supply at its initial steady state value ($\bar{m}^a = 0$) then the German money stock can only be affected by capital flows ($\frac{1}{2} \bar{m}^d$)

A home (German) fiscal expansion will trigger net-capital flows from the foreign country - i.e. increase the German money stock - if $\bar{m}^d > 0$.

From equation (A8) it can be seen that this will be the typical case if

$$(A9) \chi(1 + 2\mu\omega_1 b_1) - b_2(a_3 + 2\mu\omega_1 a_2) > 0$$

or equivalently if

$$(A10) \chi > \frac{b_2(a_3 + 2\mu\omega_1 a_2)}{(1 + 2\mu\omega_1 b_1)}$$

In the specific case of perfect capital mobility this condition will always be fulfilled.

Appendix B. The Solution to the Expectational Difference Equation for the Real Exchange Rate

This appendix follows Blanchard and Fischer (1989) p.p. 261 - 65.

We will solve equation

$$(5.4) p_t^d = \alpha E [p_{t+1}^d | t] + \beta p_{t-1}^d + x_t^d$$

$$\text{where } x_t^d \equiv \frac{\theta-L}{\Lambda} (g^d + u^d)$$

We will use the method of factorization which was introduced to economics by Sargent (1979).

First in (5.4) we take expectations based on information at time $t-1$.

This implies

$$(B1'') E[p_t^d | t-1] = \alpha E [p_{t+1}^d | t-1] + \beta p_{t-1}^d + E [x_t^d | t-1]$$

Next we factor equation (B1'') to express $E [p_t^d | t-1]$ as a lagged function of itself and of expectations of current and future values of x^d , $E [x_{t+i}^d | t-1]$, $i \geq 0$.

To do so we use the lag operator, L , which operates on the time subscript of a variable (not on the time at which the expectation of that variable is held)

$$L E [p_{t+i}^d | t-1] = E [p_{t+i-1}^d | t-1]$$

so that in particular,

$$L E [p_{t+1}^d | t] = E [p_t^d | t] = p_t^d$$

For convenience, we also introduce the forward operator, $F = L^{-1}$.

Thus

$$FE [p_{t+i}^d | t-1] = E [p_{t+i+1}^d | t]$$

This last step is an application of the law of iterative expectations²¹⁾.

Since in case of rational expectations individuals avoid systematic prediction errors, expectations are based on the most recent information set i.e. Ω_t .

Using the definitions of F and L, we can write (B1'') as

$$(B8) [-\alpha F + 1 - \beta L] E [p_t^d | t-1] = E [x_t^d | t-1]$$

The next step is to factor the polynomial in parentheses. To do so, we rewrite (B8) as

$$(B9) [F^2 - \frac{1}{\alpha} F + (\frac{\beta}{\alpha})] LE [p_t^d | t-1] = (-\frac{1}{\alpha}) E [x_t^d | t-1]$$

We can factor the polynomial

$$\{F^2 - [1/\alpha]F + (\beta/\alpha)\} \text{ as } (F - \lambda_{1d})*(F - \lambda_{2d}), \text{ where } \lambda_{1d} + \lambda_{2d} = \frac{1}{\alpha} \text{ and } \lambda_{1d}\lambda_{2d} = \frac{\beta}{\alpha}$$

If one of the roots is smaller than one in absolute value and the other larger than one in absolute value (5.4) will be saddlepoint-stable i.e. the differences model will have the saddlepoint property.

Of course the roots are

$$\lambda_{1d} = \frac{(1/\alpha) - \sqrt{\frac{1}{\alpha^2} - \frac{4\beta}{\alpha}}}{2}$$

$$\lambda_{2d} = \frac{(1/\alpha) + \sqrt{\frac{1}{\alpha^2} - \frac{4\beta}{\alpha}}}{2}$$

where (see section 5)

²¹⁾ Formally if Ω is an information set and ω a sub-set of this set, then for any X , $E [E [X | \Omega] | \omega] = E [X | \omega]$

$$\alpha \equiv \frac{\theta a_1(1-2\mu)}{\Lambda}$$

$$\beta \equiv \frac{\omega_1(1 + a_2)[1 - (1 - \theta)(1 - 2\mu)] + 2a_3 + a_1(1 - 2\mu)}{\Lambda}$$

We can rewrite (B9) as

$$(B10) (F - \lambda_{1d}) * (F - \lambda_{2d}) LE [p_t^d | t-1] = \left(\frac{-1}{\alpha}\right) E [x_t^d | t-1]$$

or

$$(B11) (1 - \lambda_{1d}L) E [p_t^d | t-1] = \left(\frac{1}{\alpha\lambda_{2d}}\right) (1 - \lambda_{2d}^{-1}F)^{-1} E[x_t^d | t-1]$$

Since $|\lambda_{2d}^{-1}| < 1$, we can expand $(1 - \lambda_{2d}^{-1}F)^{-1}$ as

$$\sum_{i=0}^{\infty} \lambda_{2d}^{-i} F^i \text{ to get}$$

$$(B12) E[p_t^d | t-1] = \lambda_{1d} p_{t-1}^d + \left(\frac{1}{\alpha\lambda_{2d}}\right) \sum_{i=0}^{\infty} \lambda_{2d}^{-i} E [x_{t+i}^d | t-1]$$

Equation (B12) gives the expectation of p_t^d as of $t-1$. The last step is to derive the solution for p_t^d . To do so, we use (B12) to get an expression for $E [p_{t+1}^d | t]$ and replace

$$E [p_{t+1}^d | t] \text{ in (5.4).}$$

This gives

$$p_t^d = \alpha\lambda_{1d} p_t^d + \left(\frac{1}{\lambda_{2d}}\right) \sum_{i=0}^{\infty} \lambda_{2d}^{-i} E [x_{t+i+1}^d | t] + \beta p_{t-1}^d + x_t^d$$

Reorganizing, and using the fact that, from the definition of λ_{1d} , $(\beta)/(1 - \alpha\lambda_{1d}) = \lambda_{1d}$, gives

$$(B13) \quad p_t^d = \lambda_{1d} p_{t-1}^d + \left(\frac{1}{1 - \alpha \lambda_{1d}} \right) \sum_{i=0}^{\infty} \lambda_{2d}^{-i} E [x_{t+i}^d | t]$$

So that

$$-p_t^d = \lambda_{1d} (-p_{t-1}^d) - \left(\frac{1}{1 - \alpha \lambda_{1d}} \right) \sum_{i=0}^{\infty} \lambda_{2d}^{-i} E [x_{t+i}^d | t]$$

Note that according to equation (3.13) $-p^d = q$. Thus

$$(B14) \quad q_t = \lambda_{1d} q_{t-1} - \left(\frac{1}{1 - \alpha \lambda_{1d}} \right) \sum_{i=0}^{\infty} \lambda_{2d}^{-i} E [x_{t+i}^d | t]$$

$$\text{Since } \sum_{i=0}^{\infty} \lambda_{2d}^{-i} = \frac{\lambda_{2d}}{(\lambda_{2d} - 1)}$$

(B14) can be rewritten as

$$(B15) \quad q_t = \lambda_{1d} q_{t-1} - \frac{\lambda_{2d}}{(\lambda_{2d} - 1)(1 - \alpha \lambda_{1d})} E [x_{t+i}^d | t]$$

where

$$x_{t+i}^d = F^i x^d = \frac{F^i(\theta - L)}{\Lambda} (g^d + u^d)$$

Thus

$$x_{t+i}^d = \frac{1}{\Lambda} \{ \theta (g_{t+i}^d + u_{t+i}^d) - (g_{t+i-1}^d + u_{t+i-1}^d) \}$$

So

$$E [x_{t+i}^d | t] =$$

$$E \left[\frac{1}{\Lambda} \{ \theta (g_{t+i}^d + u_{t+i}^d) - (g_{t+i-1}^d + u_{t+i-1}^d) \} | t \right]$$

$$\text{So } E [x_{t+i}^d | t] = \frac{1}{\Lambda} E [\theta (g_{t+i}^d + u_{t+i}^d) - (g_{t+i-1}^d + u_{t+i-1}^d) | t]$$

$$\text{Since by definition } E [u_{t+i}^d | t] = E [u_{t+i-1}^d | t] = 0$$

$$(B16) \quad E [x_{t+i}^d | t] = \frac{1}{\Lambda} (\theta g_{t+i}^d - g_{t+i-1}^d)$$

Substitution of (B16) in (B15) yields

$$(B17) \quad q_t = \lambda_{1d} q_{t-1} - \frac{\lambda_{2d}}{(\lambda_{2d} - 1)(1 - \alpha\lambda_{1d})\Lambda} (\theta g_{t+i}^d - g_{t+i-1}^d)$$

Suppose that at time $t = 0$ the European economy is in steady state with $q_0 = 0$ and that at time $t = 1$ the home government is believed to engage in a permanent 1% real deficit increase.

$$\forall i, 1 \leq i \leq \infty \quad E [g_{t+i}^d | t] = 1$$

From (B17) it can be seen that in order to clear the European money market, the real exchange rate has to jump to a value

$$q_0 = \frac{-\lambda_{2d}(\theta - 1)}{\Lambda(\lambda_{2d} - 1)(1 - \alpha\lambda_{1d})}$$

whilst the steady state effect is obtained by setting $q_t = q_{t-1}$ which yields

$$q_\infty = \frac{-\lambda_{2d}}{\Lambda(\lambda_{2d} - 1)(1 - \alpha\lambda_{1d})(1 - \lambda_{1d})}$$

Thus

$$\frac{q_0}{q_\infty} = 1 - \lambda_{1d}$$

Since in general²²⁾ $|\lambda_{1d}| \neq 1$, $\frac{q_0}{q_\infty}$ is greater or smaller than 1, so our two-country model features real exchange rate under/over shooting (Dornbusch 1976).

Appendix C. The Linearized Money Supply Rule.

We start with the standard expression for monetary accommodation of government budget deficits

$$(6.1) \Delta \hat{M} = \psi_o (\hat{G} - t \hat{Y}) \quad 0 \leq \psi_o \leq 1$$

where

\hat{M} = nominal money stock

\hat{G} = nominal government expenditure

t = average tax rate

ψ_o = fraction of the budget deficit financed by printing money and 'hats' denote absolute values.

Abstracting from taxes we get

$$(C1) \Delta \hat{M} = \psi_o \hat{g} \hat{p}$$

where \hat{g} is real expenditure and \hat{p} is the price level.

Note that simple rearrangement of (C1) yields the concept of monetary seigniorage

($\hat{S}_m \equiv \Delta \hat{M} / \hat{p}$), which is widely used in empirical research²³⁾.

$$(C2) \hat{S}_m = \psi_o \hat{g}$$

Of course (C2) measures the actual wealth transfer which the private sector has to make in order to receive base money in the amount \hat{M} from the central bank.

(C1) can be re-written as

$$(C3) \hat{M} = L\hat{M} + \psi_o \hat{g} \hat{p}$$

²²⁾ $\lambda_{1d} = 1$ if $\theta = 0$ (no nominal rigidities) and $\mu = 1/2$ (real interest parity).

²³⁾ For an interesting exposition about different concepts of seigniorage see Klein and Neumann (1990).

where L is the backward shift operator.

Taking total differentials of (C3) yields

$$(C4) \, d\hat{M} = L \, d\hat{M} + \psi_o \, \hat{g} \, d\hat{p} + \psi_o \, \hat{p} \, d\hat{g}$$

Remember that in the model

$m \equiv d \ln \hat{M} = d\hat{M}/\hat{M}$, where \hat{M} is the initial steady state value of the nominal money stock,

Therefore

$$(C5) \, d\hat{M}/\hat{M} = L \, d\hat{M}/\hat{M} + (\psi_o \, \hat{g} \, d\hat{p})/\hat{M} + (\psi_o \, \hat{p} \, d\hat{g})/\hat{M}$$

or:

$$(C6) \, d\hat{M}/\hat{M} = L \, d\hat{M}/\hat{M} + (\psi_o \hat{p} \hat{g})/\hat{M} * d\hat{p}/\hat{p} + (\psi_o \hat{g} \hat{p})/\hat{M} * d\hat{g}/\hat{g}$$

where $d\hat{p}/\hat{p} \equiv p$, $d\hat{g}/\hat{g} \equiv g$ thus

$$(C7) \, m = Lm + ((\psi_o \hat{p} \hat{g})\hat{M}^{-1})p + ((\psi_o \hat{g} \hat{p})\hat{M}^{-1})g$$

Note that $(\hat{g}\hat{p})/\hat{M}$ is the initial nominal government deficit in terms of the initial (nominal) money stock. Using ψ_m as an abbreviation for $\hat{M}/(\hat{g}\hat{p})$ we end up with

$$(C8) \, \Delta m = \psi_o/\psi_m(p + g)$$

Using ψ as shorthand for ψ_o/ψ_m we get

$$(6.2) \, \Delta m = \psi (g + p)$$

note that if $\psi_m = 1$, $\psi = \psi_o$

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